

Comparative Study of a Two Different DC/DC Converter for DC Motor Drive using PV System

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ABSTRACT: The paper proposes a topology of the performance comparison of synchronous single-ended primary-inductor converter (SEPIC) and synchronous Zeta focusing on the output voltage and their performance of the system. The conventional SEPIC and Zeta converters operated in Buck and Boost modes were modified to the synchronous SEPIC and synchronous Zeta converters to improve the converter efficiency. This paper presents a comparative study on DC motor drive fed two different DC to DC converter for stand-alone PV system. The operating voltages are set up according to the requirements of the load conditions, whether it is operating in buck mode or boost mode [4]. The simulation is performed for the DC motor using both converters using PSIM 9.3.

KEYWORDS: Stand-alone PV systems, DC motor drive, Synchronous SEPIC converter, Synchronous Zeta converter.

I. INTRODUCTION

From the several constraints of the environment problems and also requirement of the power for the daily life we have to think about the problems and solution for the problems. Due to the rapid increase in the power demand and growing concern on global warming, the renewable energy sources plays an important role in the field of electrical energy sector for the production of supply. The applications of renewable energy sources are found in house-hold, stand-alone, and grid-connected systems. All over the world greenhouse effect is considered one of the major problems. The causes for the global warming are emission of greenhouse gases such as carbon dioxide and carbon monoxide. The major contributors for those gases are use of conventional energy sources such as coal based power plants.

In India there is huge gap between demand and availability of electrical energy. Currently India facing twin challenges.

- To increase energy production to meet the demand.
- Limit the emission of greenhouse gases.

Both the challenges can be tackled by use of non-conventional energy sources such as solar energy.

Solar energy plays a vital role in the present days in the world because it is inexhaustible, clean and friendly in nature. Solar photovoltaic is based on the photovoltaic effect to transform a part of energy into electricity [1]. This energy sources requires a proposed DC-DC converter in order to increase the efficiency. This project is aims to perform the comparison of synchronous single-ended primary-inductor converter (SEPIC) and synchronous ZETA converter for stand-alone PV systems. In the synchronous converter the diode is replaced by MOSFET [2]. The advantage of this configuration is that the second MOSFET will have lower voltage drop compared to diode which results in higher efficiency. In order to increase the radiation falling on solar panel the MPPT technique called perturb and observe (P&O) technique is used[1][6].

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 9, May 2016

II. PROPOSED SYSTEM

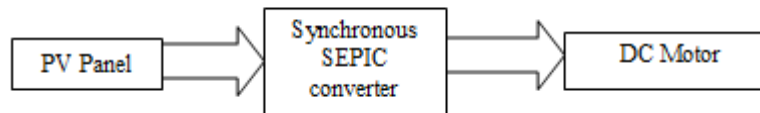


Fig.1: Block diagram of proposed system of Synchronous SEPIC converter.

The above block diagram shows the proposed system of the synchronous SEPIC converter. The availability of solar energy is not constant throughout the day. In order to maintaining the input voltage to converter constant, so MPPT Technique is used for the PV panel.

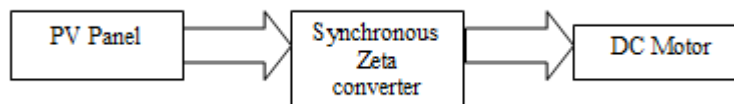


Fig.2: Block diagram of proposed system of Synchronous Zeta converter.

The above block diagram shows the proposed system of the synchronous Zeta converter. The availability of solar energy is not constant throughout the day. In order to maintaining the input voltage to converter constant, so MPPT Technique is used for the PV panel.

III. METHODOLOGY

A. PHOTOVOLTAIC PANEL

PV array is a p-n junction semiconductor, used to convert sunlight into electrical energy. When the incoming solar energy exceeds the band-gap energy of the module, photons are absorbed by materials to produce electricity. The cells in the PV array are tied in series or parallel and the electrical power of the PV array depends upon the solar irradiance, panel temperature and the operating current and voltage relationship. The current voltage characteristics, (V-I) characteristic of PV array is a complex and non-linear function. The following exponential model is used to describe and predict the behaviour of our proposed photovoltaic module.

$$P_{max} = \frac{V_{op} \cdot I_{sc}}{1 - \exp(-1/b)} * [1 - \exp(\frac{V_{op}}{bV_{oc}} - \frac{1}{b})] \quad (1)$$

$$b = \frac{(\frac{V_{oc}}{V_{oc}} - 1)}{\ln[1 - \frac{P_{max}}{V_{op} \cdot I_{sc}}]} \quad (2)$$

$$R_{op} = \frac{V_{op} - V_{op} \cdot \exp(-\frac{1}{b})}{I_{sc} - I_{sc} \cdot \exp(\frac{V_{op}}{bV_{oc}} - \frac{1}{b})} \quad (3)$$

Where, I_{sc} is the short circuit current, V_{oc} is the open circuit voltage, I_{op} is the optimal current and V_{op} is the optimal voltage. The value of b is very small and it is distinct and unique for every solar panel and does not vary with changes in irradiance and solar cell temperature.

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Special Issue 9, May 2016

A. SYNCHRONOUS SEPIC CONVERTER AND SYNCHRONOUS ZETA CONVERTERS

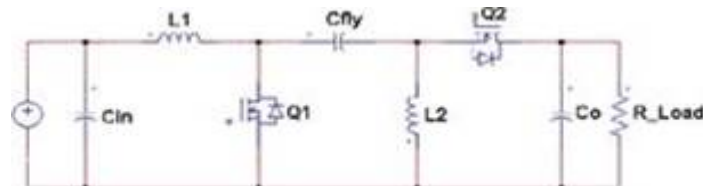


Fig.3: Equivalent circuit of Synchronous SEPIC converter.

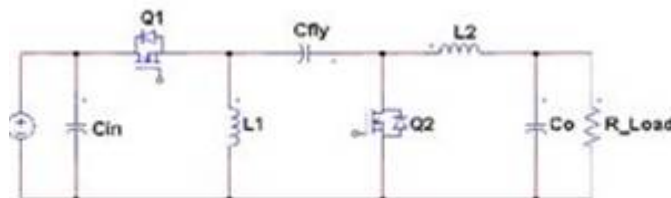


Fig.4: Equivalent circuit of Synchronous Zeta converter.

Fig. 3 and Fig. 4 above shows the equivalent DC-DC converters (synchronous SEPIC converter and synchronous Zeta converter) [5][3] consists of,

1. C_{in} - Input capacitor.
2. C_o - Output capacitor.
3. L_1 and L_2 - Coupled inductors.
4. C_{fly} - Coupling capacitor.
5. $Q1$ and $Q2$ - Power MOSFET.

a. Duty cycle

Assuming 100% efficiency, the duty cycle, D for synchronous SEPIC converter and synchronous ZETA converter operating in CCM is given by

$$V_o = V_{in} \times \left[\frac{D}{1-D} \right] \quad (4)$$

b. Component selection for Synchronous SEPIC and Synchronous zeta

$$L1 = \frac{V_{in,max} \cdot V_o}{I_{ripple} \cdot f \cdot (V_{in,max} + V_o)} \quad (5)$$

Where, $L1 = L2$

$$I_{DC} = \frac{I_o \cdot V_o}{V_{in,min} \cdot \eta \cdot f} \quad (6)$$

$$I_{sat} \geq 1.15 \times I_{DC} \quad (7)$$

$$C_{fly} = \frac{I_o \cdot V_o}{(V_{in} + V_o) \cdot f \cdot V_{ripple}} \quad (8)$$

$$C_{in} = I_o \cdot \frac{1}{2 \cdot f \cdot 0.18V} \quad (9)$$

$$C_o = \frac{I_{ripple}}{2 \cdot V_{ripple} \cdot f} \quad (10)$$

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Special Issue 9, May 2016

IV. SIMULATION RESULTS

The simulation is performed for DC motor using both converters using PSIM 9.3. Below waveforms shows the output voltages and Inductor currents of synchronous SEPIC and Zeta converter, here we see that settling time is less for synchronous Zeta and from the waveforms the Output Voltage of synchronous Zeta converter is high. The simulation circuit of open loop synchronous SEPIC and Zeta converter with renewable sources is as simulated and results are shown. Here the PV panel is connected to the synchronous SEPIC and Zeta converter with a constant temperature of 250 C and radiation of 1000 W/m² [6], general specifications for these converters are

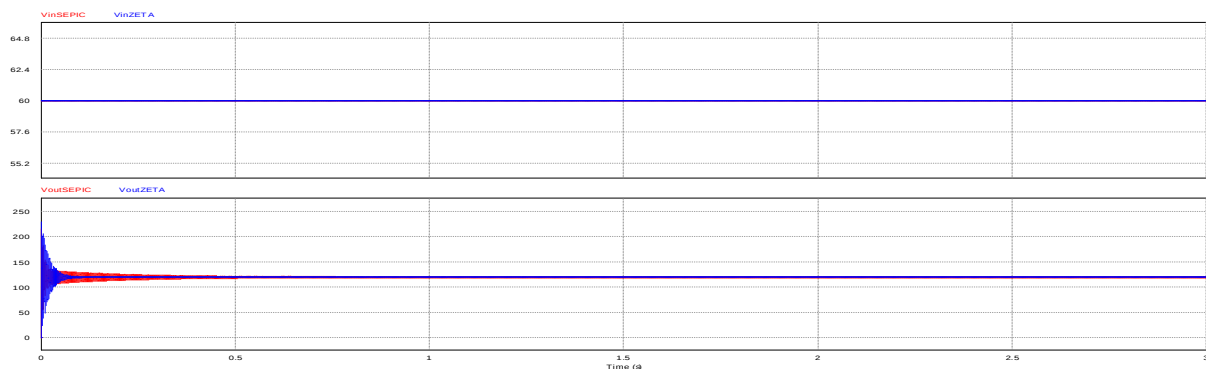


Fig.5: The Waveforms of DC input Voltage, DC Output Voltage.

Both the circuits are simulated in the PSIM software for the DC input voltage of 60v. The above waveforms show the DC input voltages of both the converter for the Rload and obtained DC voltages for the given input for both the converters.

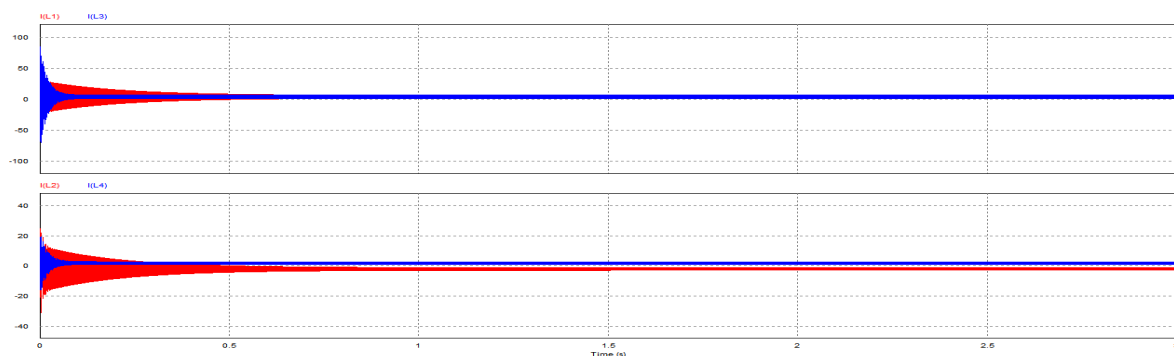


Fig.6: The Waveforms of Inductor currents of both the converters.

The above waveforms show the inductor currents IL1, IL2, IL3 and IL4 of both the converters and comparing both the inductor currents. Comparing the inductor currents IL1, IL2 of synchronous SEPIC converter and the inductor currents IL3, IL4 of the synchronous Zeta converter.

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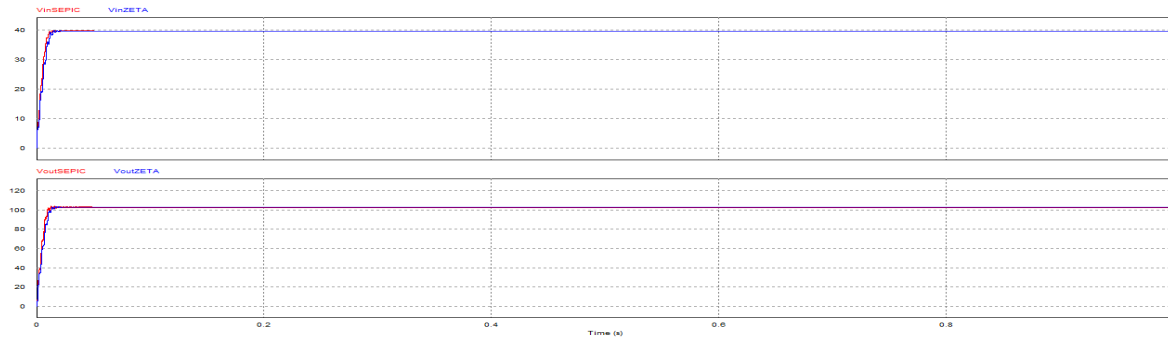


Fig.7: Above Waveforms shows the DC input and Output voltage of synchronous SEPIC and synchronous Zeta converter for the PV input systems.

The above waveforms show the DC input and Output voltage of synchronous SEPIC and synchronous Zeta converter for the PV input systems. The main circuit of both the converters with PV input system is simulated in PSIM software with suitable design parameters.

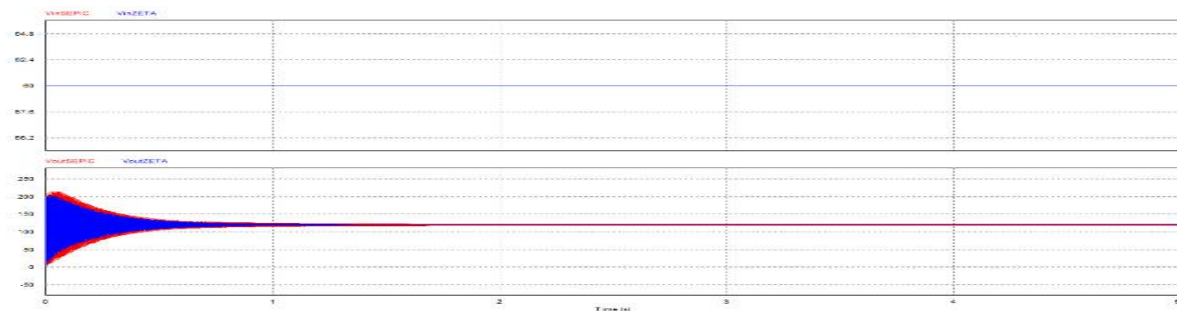


Fig.8: The Waveforms of DC input Voltage, DC Output Voltage.

Both the circuits are simulated in the PSIM software for the DC input voltage of 60v. The above waveforms show the DC input voltages of both the converter for the DC motor load and obtained DC voltages for the given input for both the converters.

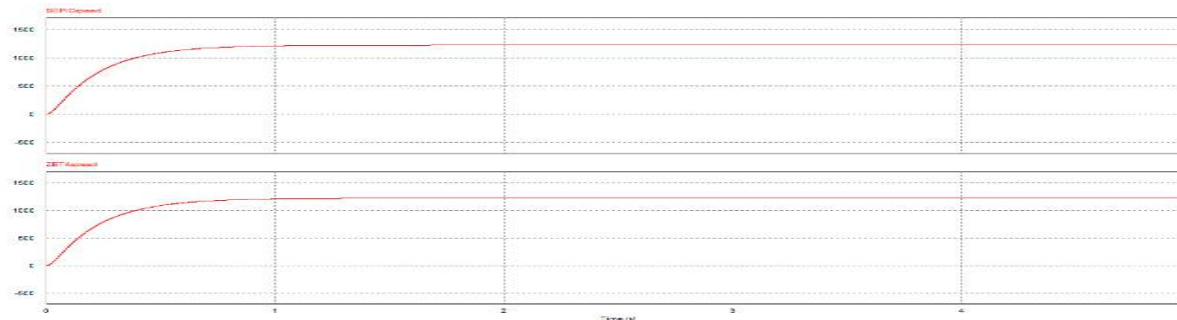


Fig.9: Above Waveforms shows the speeds of the DC motor fed by both the converters.

- The Obtained speeds of synchronous SEPIC is 1163rpm and synchronous Zeta is 1164rpm of rated speed 1200rpm.
- Speed regulation of synchronous Zeta is better than synchronous SEPIC converter.

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DC motor ratings:

Rated voltage: 120 V

Rated current: 10 A

Rated speed: 1200 rpm

V. CONCLUSION

The performance of both synchronous SEPIC and synchronous Zeta converter compared for R-load and separately excited DC motor.

1. Both converters supports wide range of buck and boost capabilities
2. Energy storage and transfer depends on the capacitors of the converter.
3. From the reference of conventional converters the diode is replaced by the MOSFET and it has less voltage drop compared to the load.
4. The output voltage of synchronous Zeta converter is better than the synchronous SEPIC converter from both theoretical and practical aspects.

For the DC motor drive that is for separately excited DC motor noticed that the speed regulation of synchronous Zeta converter is better than synchronous SEPIC converter.

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